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THE ILLINOIS CONSUMER'S ROLE
IN ENERGY CONSERVATION

by
Clark W. Bullard III

June 13, 1973

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This work was supported by a grant from the National Science Foundation.

ABSTRACT

The Illinois contribution to the GNP is examined to determine the energy required to manufacture, deliver, and sell the goods and services which make up the State product. The analysis is based on a method for converting dollar expenditures to total energy requirements.

It is shown that more energy is burned in Illinois than is mined, and still more is required to produce the goods and services sold in the Illinois marketplace. Thus, Illinois imports "direct" energy, in the form of oil and gas, and is also a net importer of "indirect" energy, that embodied in goods and services manufactured with energy burned in other states.

Energy demands resulting from personal consumption expenditures are analyzed in detail. Specific suggestions are made to help consumers spend their dollars in ways that save energy directly and indirectly.

The energy impact of state and local government purchases is also determined, and it is shown how citizens, through their elected representatives may act to conserve energy. Three major areas are suggested: provide economic incentives, increase the energy-awareness of consumers, and curtail construction of public facilities which induce wasteful energy use by consumers.

Finally, the potential impact of energy conservation on the environment is discussed. It is shown that if each Illinois consumer reduced his energy demand by only 2%, the savings would exceed the output of a hydroelectric facility the size of Glen Canyon Dam.

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INTRODUCTION

The purpose of this paper is to examine the role of consumers in energy conservation. I will begin by discussing several reasons for conserving energy. Next, the components of energy demand will be examined in an effort to pinpoint those consumer decisions which result in the consumption of energy resources. Finally, I will suggest several methods by which Illinois consumers can save energy, and will call attention to the potential benefits of doing so.

Many reasons can be given for conserving energy, depending upon one's point of view. We can view energy conservation as a tool for coping with an impending energy crisis; or we may view it as an ethic in itself, part of a larger concern for conservation and wise use of all natural resources.

Both points of view are common today. Since many energy conservation measures (e.g., reducing highway speed limits) can be implemented much more quickly than supplies can be increased (e.g., building the Trans-Alaska pipeline), energy conservation is an effective tool for dealing with the impending fuel shortages. In the longer run, conservation policies may be effective tools for lessening our dependence on foreign energy sources. The payoff of such policies might be larger than we expect, when we consider the recent request by the Defense Department for a new series of aircraft carriers, at one billion dollars apiece, to protect our Atlantic tanker fleet.

From the conservationist's point of view, energy conservation is considered to be essential in the long run because of the finite nature of our energy reserves, and because of uncertainties and risks surrounding the development of new energy sources. In the short run, the conservationist shares the concern of the general public about the adverse environmental

impacts associated with virtually every phase of energy development, distribution and consumption. Conserving energy is therefore seen as a direct method for reducing environmental damage resulting from strip mining and oil spills at one end, to air pollution and radioactive waste at the other.

Whatever one's reasons for conserving energy, much needs to be done before effective and equitable energy saving policies are developed and implemented. What is needed first is a closer examination of the components of energy demand.

THE ELEMENTS OF ENERGY DEMAND

It is customary to present energy demand statistics in a way which identifies the sector of the economy where the energy is consumed¹ (Fig. 1). It would appear, therefore, that the individual consumer has direct control over only about one-third of the total U. S. energy demand, for that is the portion accounted for by residential demands and fuel for private automobiles. Similarly, it might appear that commerce and industry are responsible for the bulk of the energy consumption, and therefore should assume primary responsibility for conservation.

While these observations may be correct, the fact remains that individual consumers are responsible not only for their own direct consumption of energy, but also for the energy consumed by commerce and industry to provide them with the goods and services they demand.

The Energy Cost of Goods and Services

Recent research by Herendeen² has made it possible to determine the energy required, directly and indirectly, to manufacture, transport and deliver the goods and services which make up our gross national product. The method is an extension of the standard input/output analysis of the U. S. economy, and therefore depends on data from the Census Bureau and other sources.³ The latest data available are for 1963, but they nevertheless provide valuable insight into the components of energy demand. The results of the analysis are a set of coefficients (Btu per dollar) for 362 sectors of the economy. These coefficients represent the "indirect" energy embodied in products, the energy consumed by commerce and industry to make, transport, and sell the products. For items which contain energy (e.g., coal, oil, gas, electricity) their "direct" energy content is added to the indirect to give the total energy coefficient. Multiplying these coefficients by dollar cost of an item gives its total energy content.

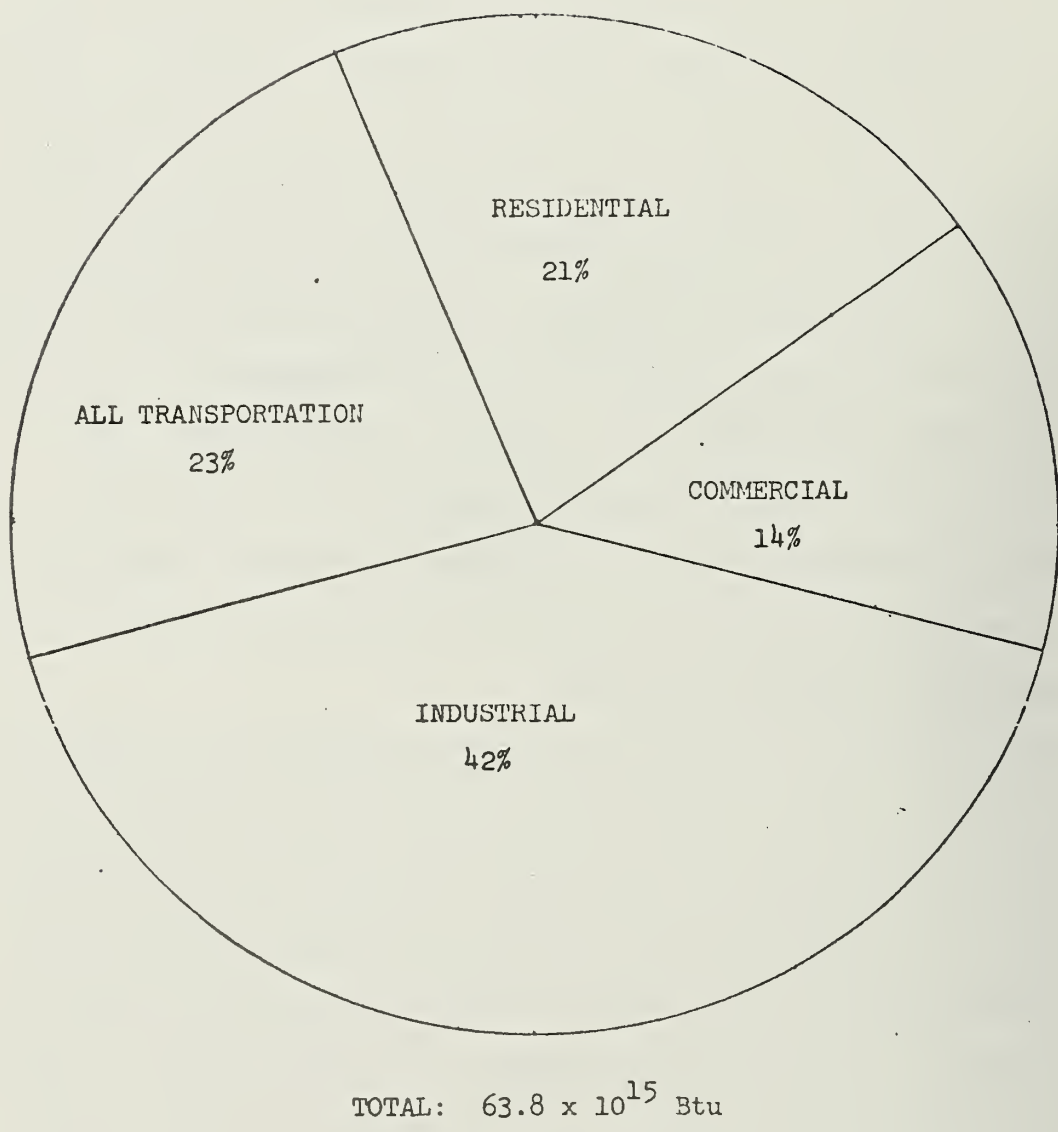


FIGURE 1. UNITED STATES DIRECT ENERGY CONSUMPTION, 1969

To determine Illinois' energy demand, we need an estimate of the GNP for Illinois in 1963.⁴ An estimate is available for a somewhat more coarse 82 sector disaggregation of the GNP. In this paper, the coefficients from Ref. 1 were aggregated to 82 sectors, weighted by the 362 sector national final demand. (For details of these and other calculations, the reader is referred to the Technical Appendix.)

Illinois Energy Demand

Using the Illinois total final demand for 1963, and converting to energy using the 82 coefficients obtained above, a direct and indirect energy demand of 281 million Btu per capita was obtained. In Fig. 2 this is compared with the energy mined⁵⁻⁷ in Illinois and the energy consumed (burned) in 1963.⁵ It can be seen that Illinois was a net importer of direct energy, burning 244 million Btu per capita while mining only 159 million. In addition, it appears that sales in the Illinois marketplace resulted in a demand for more energy than was burned in the state.⁸⁻¹⁰ Thus Illinois was a net importer of indirect energy, as well as direct energy. Put another way, Illinois enjoyed the benefits of high energy use, without carrying a proportionate share of the adverse environmental effects of mining and burning that amount of energy.

Fig. 3 compares the direct and indirect per capita energy consumption in Illinois with the national average. It shows that the Illinois energy demand was 10% higher, with the difference split almost evenly between direct and indirect energy. The increased direct energy might be attributed to the fact that most of Illinois population is north of the national population centroid, thereby requiring more space heating energy. The higher indirect demands may reflect the fact that the Illinois per capita GNP was higher than the national average in 1963.

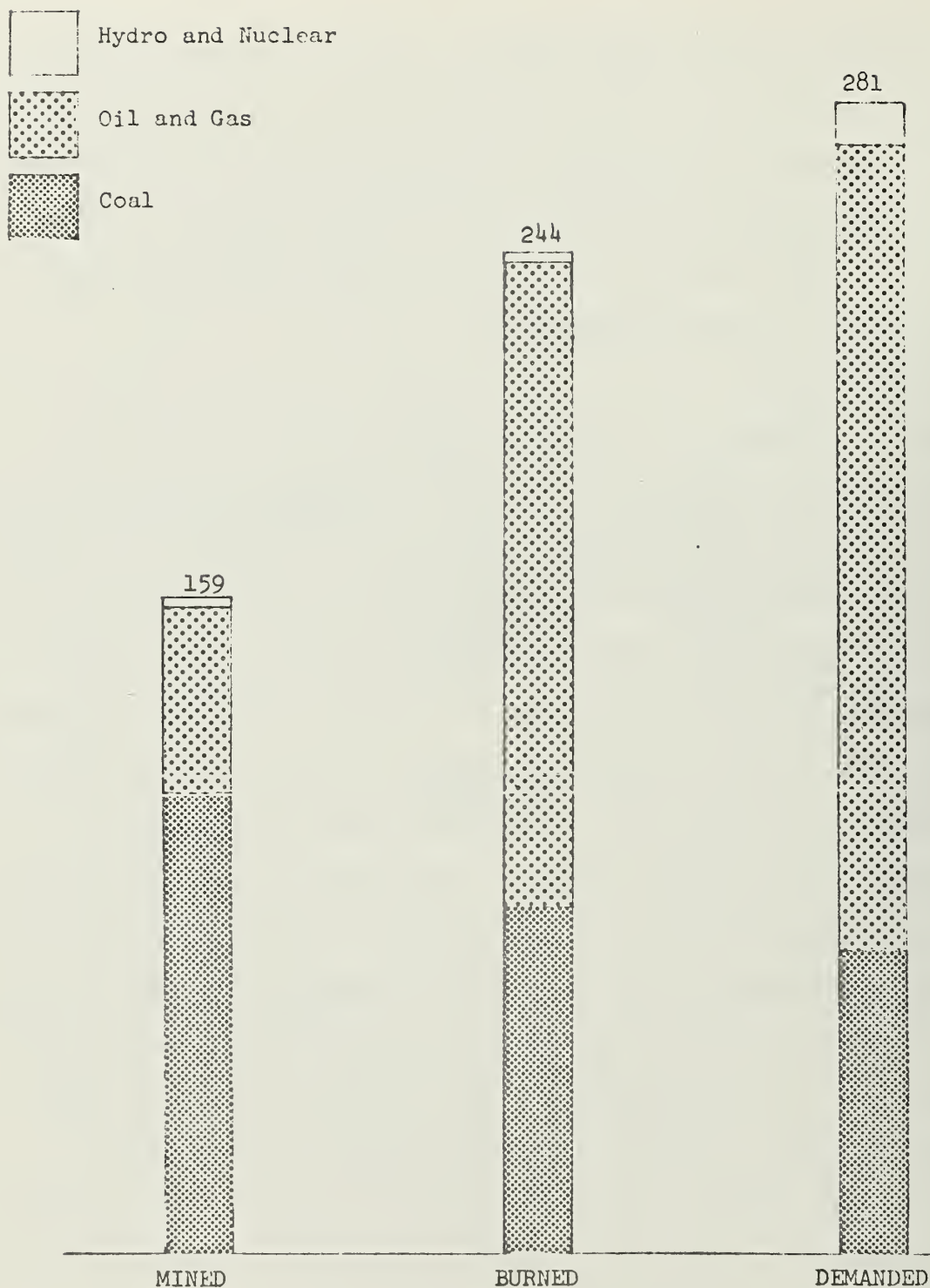


FIGURE 2. ENERGY PRODUCTION, CONSUMPTION, AND DEMAND IN ILLINOIS, 1963 (10^6 BTU/CAPITA)

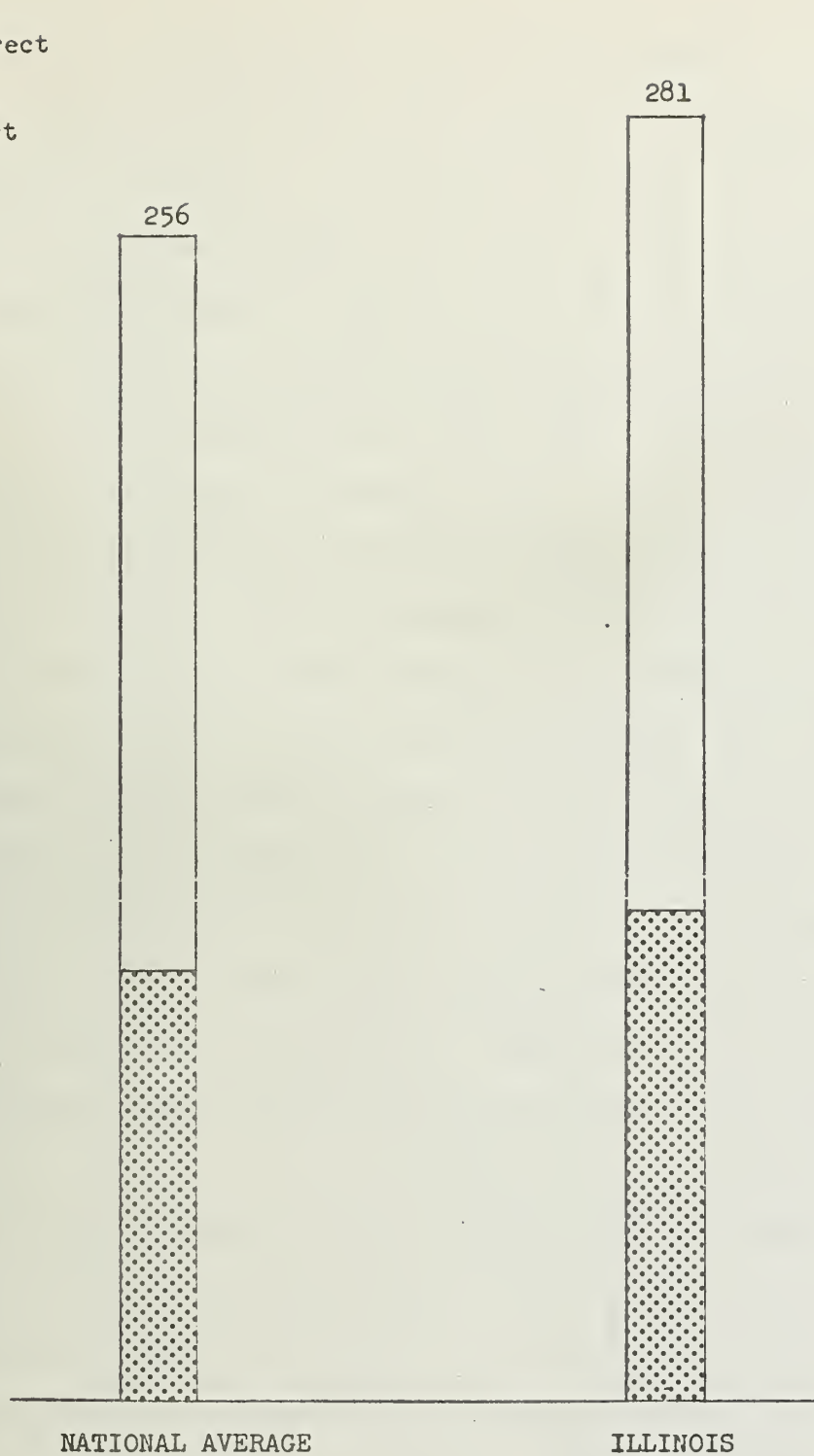


FIGURE 3. 1963 PER CAPITA ENERGY DEMAND (MILLION BTU)

OPPORTUNITIES FOR ENERGY CONSERVATION

Before examining the Illinois energy demand more carefully and suggesting specific methods for conservation, it would be interesting to speculate on the potential payoff of even modest energy conservation measures. As we have noted above, Illinois per capita energy demand exceeded the national average by approximately 10%, or about 25 million Btu per person per year. This excess, when expressed in Btu, is a difficult concept to grasp. Fig. 4 attempts to relate this excess consumption to a well-known energy/environment controversy in 1963.¹¹ The controversy centered around the decision to flood Glen Canyon and Rainbow Bridge National Monument on the Colorado River by constructing a hydroelectric dam. Fig. 4 compares the annual primary* energy production of Glen Canyon dam with the amount of energy by which Illinois consumption exceeded the national average in 1963. If Illinois energy demand at that time were reduced by only 1.7% (i.e., if it had been 276 million Btu/capita rather than 281), the national energy demand would have been reduced by the amount of one Glen Canyon dam. This gives some indication of the far-reaching impact that could result from even modest energy savings on the part of the citizens of just one state.

Today perhaps the best known controversy involving energy and the environment is concerned with the proposed Trans-Alaska pipeline. The pipeline and its associated highway would bisect the largest remaining wilderness area on the American frontier. It is expected to provide 2 million barrels of oil per day by 1980, or about 18 million Btu/person per year. Fig. 5 compares the U. S. per capita energy demand in 1970 with the projected 1980 demand. It can be seen that a 35% increase in per capita energy demand

*The primary energy production of a hydroelectric facility is defined as the amount of fossil fuel which would be needed to produce an equivalent amount of electricity.

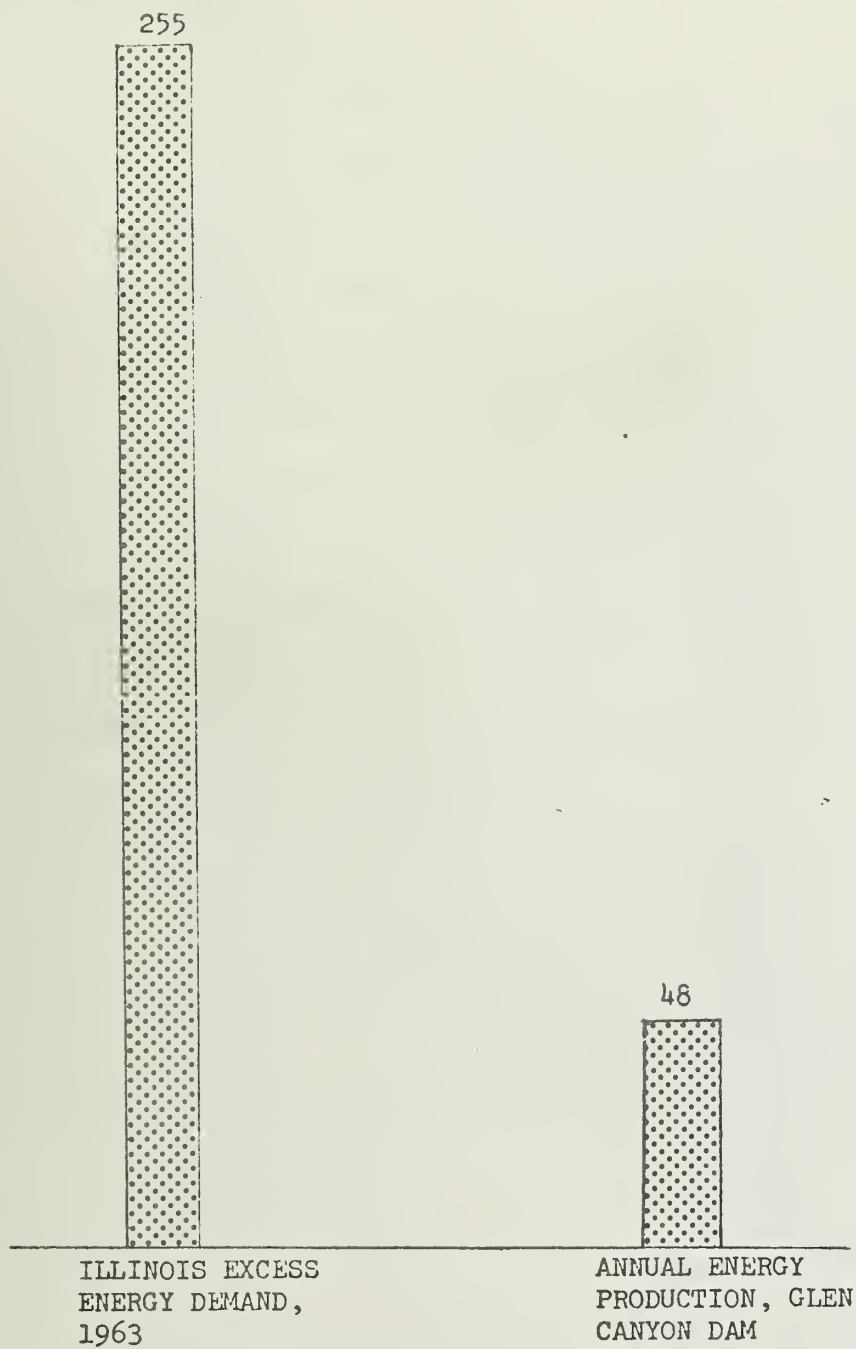


FIGURE 4. 1963 ILLINOIS ENERGY DEMAND IN EXCESS OF NATIONAL AVERAGE, COMPARED TO CAPACITY OF GLEN CANYON DAM (TRILLION BTU)

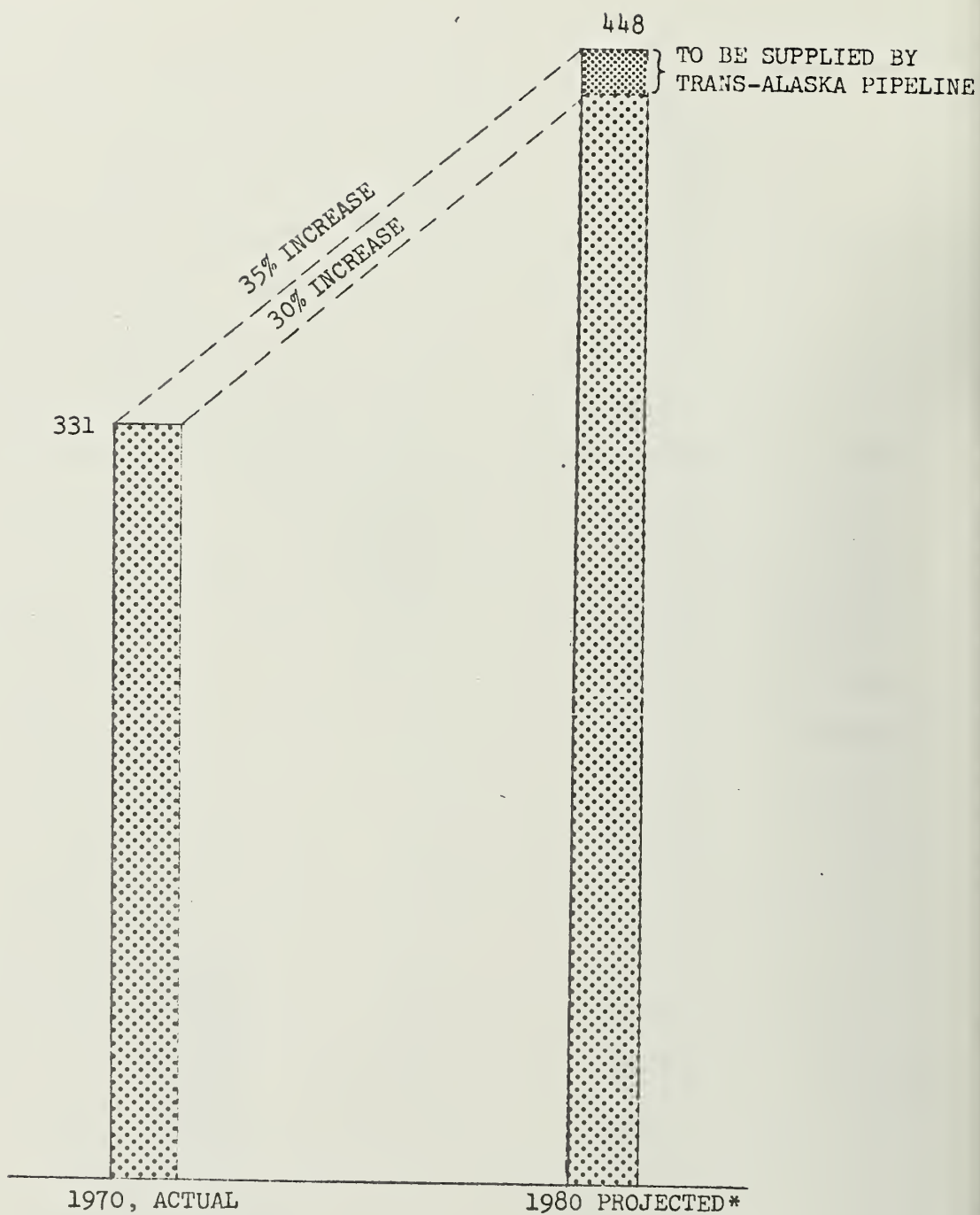


FIGURE 5. U. S. PER CAPITA ENERGY DEMAND, 1970 AND 1980.
(MILLION BTU)

*Based on a 1980 population of 229 million.

is expected.¹² If instead it increased only 30%, the 1980 energy needs would be less than the predicted needs by the amount the Trans-Alaska pipeline would supply.

Personal Consumption Expenditures

This is the area containing the most opportunities for energy conservation by individuals. Table 1 shows that personal consumption expenditures (PCE) accounted for nearly 70% of Illinois' per capita energy demand in 1963. In Fig. 6 the energy demand resulting from all 82 types of expenditures has been aggregated to 18 categories to provide a better picture of the ways Illinois consumers demand energy, directly and indirectly. As might have been expected, purchases of direct forms of energy head the list. Keep in mind though that the figures include the heat wasted at power plants, transmission losses, and refining energies. Food and drugs rank third, perhaps surprising until one considers the amount of energy expended processing and packaging most of the foods we buy. These three categories account for two-thirds of the total PCE energy.

Two types of "hidden" costs are shown explicitly in Table 1.

Wholesale and retail trade energy, including that required to heat, air condition and illuminate stores and warehouses, as well as the energy required

CATEGORY	MILLIONS OF DOLLARS	TRILLIONS OF BTU	PERCENT OF ENERGY DEMAND
Personal Consumption Expenditures	22304	1966	69
Gross Private Capital Formation	4497	285	10
Net Inventory Change	435	42	1
Gross Foreign Exports	2142	292	10
State & Local Govt. Expenditures	3097	131	5
Federal Government Expenditures	2315	148	5

TABLE 1. DOLLAR COMPONENTS OF THE GNP AND ASSOCIATED ENERGY DEMANDS, ILLINOIS, 1963

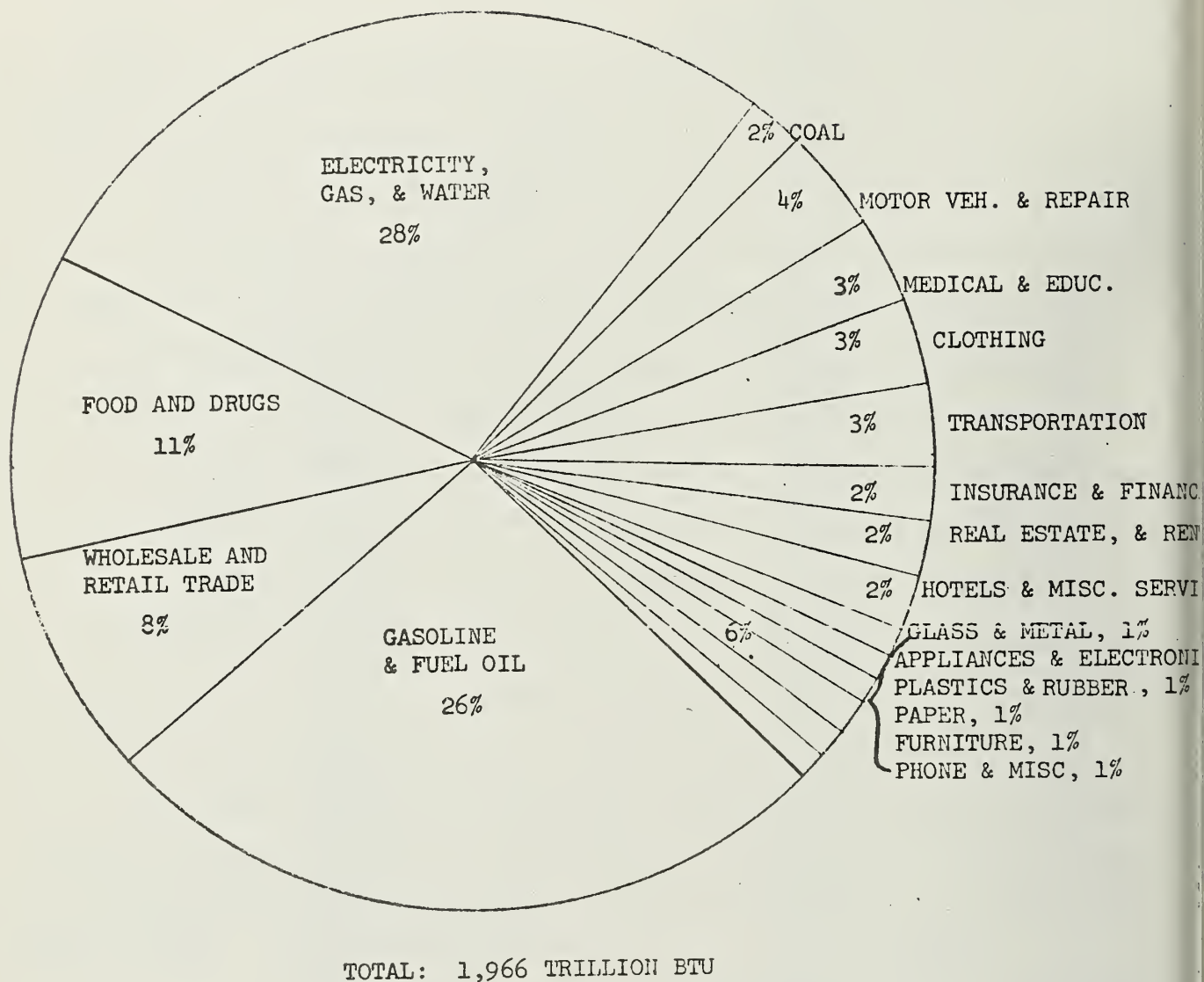


FIGURE 6. ENERGY DEMAND DUE TO ILLINOIS PERSONAL CONSUMPTION EXPENDITURES, 1963.

to manufacture items needed to operate and maintain these establishments, account for 8% of the individual consumer's energy demand. The other hidden cost, the transportation energy required to deliver goods from the factory to our homes, accounts for 3% (This is an overestimate because it includes all purchases of passenger and freight transport by individuals). Other major items include motor vehicle manufacture and repair (4%), medical and educational expenses (3%), and clothing (3%).

It might first appear surprising that the purchase of items quite energy intensive in themselves (glass and metal products, plastics, appliances, etc.) account for a relatively small portion of an individual's total energy budget. This is because such a small portion of the individual's dollar expenditures are allocated to these products. One wonders how those percentages might change as we become more affluent and spend more on such luxuries.

Within each of the categories listed, there are many opportunities for individual consumers to consume less energy. The most obvious is in the area of home space heating. It is well known that heating by direct fuel use is roughly twice as energy efficient as heating electrically. This is due to the immense quantities of heat wasted at electric power plants. Besides selecting a particular type of furnace, the consumer may also choose to insulate his home. It has been determined that the owner of a gas heated home could realize energy savings of more than 40% at no economic penalty. The owner of an electrically heated home could save the same amount of energy while reducing his heating costs by almost one-third.¹³

The second area in which significant energy savings could be realized is gasoline consumption. There are at least three different ways in which consumers could act to save gasoline. The first would be to use

their automobiles less often, relying more on mass transit, bicycling, and walking. The second would be to buy smaller, more efficient automobiles, foregoing such energy consuming extras as air conditioning and automatic transmissions. The third would be to operate existing vehicles in a more efficient manner, including more frequent tune-ups, driving slower, and joining car pools.

In the area of food purchases, consumption of over-packaged, over-processed foods could be reduced. An example would be purchasing beverages in refillable, rather than throwaway containers. The energy savings resulting from a complete switch to returnables has been estimated by Hannon¹⁴ at 15 billion kwh annually, the equivalent of the output of more than three Glen Canyon dams.

More detailed research on other consumer alternatives is underway at the University of Illinois. Soon estimates of the energy cost of frozen vs. fresh vs. canned foods, cloth vs. paper towels, automatic vs. manual dishwashing, etc. will be available. But in the meantime, consumers must develop an awareness of the energy cost of the things they buy. It will be necessary for consumers to look beyond the supermarket or the retail store and consider the total energy cost of goods and services. One does not need to be an expert to realize that it takes more energy to mine ore and manufacture a beverage can than it takes to wash and refill a bottle that can be reused many times.

Further energy savings can result from more substantial lifestyle changes such as hanging clothes out to dry instead of using a dryer, replacing the Sunday drive with a long walk or a bicycle trip, living in a smaller home, etc.

State Government Expenditures

Another way in which Illinois consumers can conserve energy is to act through their elected representatives. Fig. 7 shows the contribution to Illinois energy demand made by State and local government purchases. It can be seen that the largest part of the energy budget is devoted to construction and maintenance operations. While the energy involved is only a few percent of Illinois' total energy demand, the nature of the facilities under construction can have a far-reaching impact on future personal consumption of energy.

Let us examine the implications of the State of Illinois construction budget. Millions of dollars are being spent on highways and airports to promote auto and air travel, the two most energy intensive forms of transportation known.¹⁵ It may be time to re-evaluate the role of State government in rail transportation. The State is constructing buildings with windows that do not open; a breath of fresh air may help in more ways than one. Reservoirs are being built in downstate Illinois for the expressed purpose of inducing Chicagoans to drive and visit them; bringing the parks to the people might be a better idea. These examples illustrate the possibilities for consumers, through their government, to play a larger role in energy conservation.

Energy conservation must find its way into comprehensive land use planning. Just as an architect can design a building to minimize its operating energies, so may an urban planner design a city to conserve transportation, heating and other energies.

It may be time to reinterpret the "public interest" in the administration of the Illinois Public Utilities Act. The rate structures, as they now exist, do not provide adequate incentives for conserving energy; and

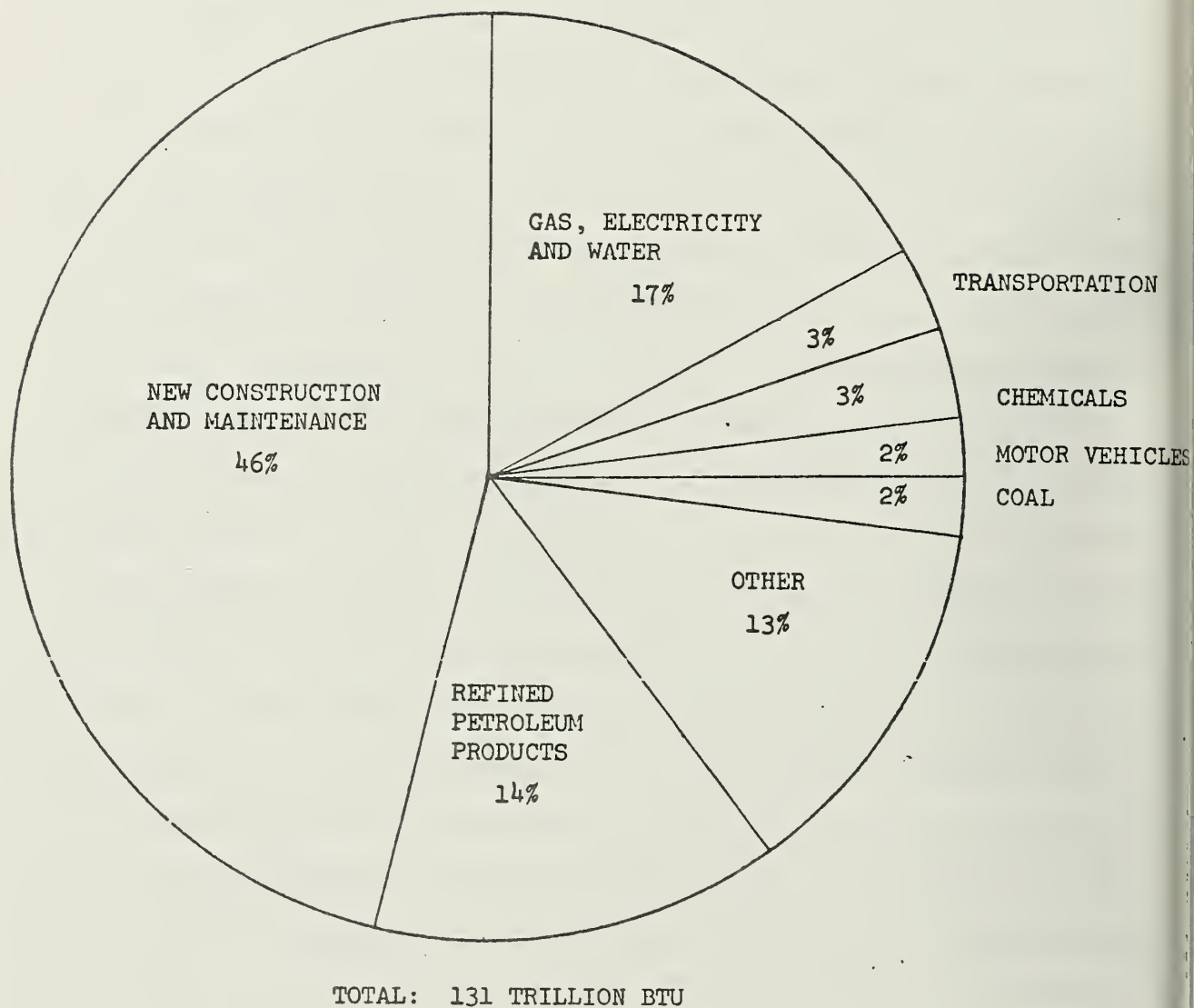


FIGURE 7. ENERGY DEMAND DUE TO ILLINOIS STATE AND LOCAL GOVERNMENT EXPENDITURES, 1963.

it is in the public interest to conserve energy. Additional incentives might include an energy tax or a tax on the sale of gas-guzzling vehicles.

The State has a role to play in public education and consumer awareness, and there is much room for increasing the energy-awareness of consumers. Appliance labeling and other measures might be implemented to help consumers help themselves.

SUMMARY

There are many reasons for conserving energy, and there are many ways to conserve energy. In fact, there are so many ways that it seems that no single action by any one individual could have a significant impact. This is the crux of the problem, and it must be solved in two ways.

First, each consumer must adopt not one, but many different energy conservation practices. I have emphasized that decisions to consume energy are made by each and every person many times per day.

Second, many or all consumers must act to save energy. Together, the citizens of Illinois can conserve significant amounts if each does his small part.

It is difficult to encourage consumers to conserve energy when, in some cases, there is an economic penalty for doing so. Through their government, consumers can act to provide economic incentives for using mass transit, for insulating homes, and for conserving energy at home. Finally, they can request from their government the information required to make energy conservation a factor in their everyday decisions.

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TECHNICAL APPENDIX

I. Energy Demand Statistics

The data for Fig. 1 were taken from Ref.1, Table II-3. In that table, electric utility waste heat and natural gas field use were treated as separate demand sectors. I prorated these quantities over electric and natural gas demands by the other sectors.

II. Energy Coefficients

Indirect energy coefficients, E , for the 362 sector (4 digit) economy were obtained from Ref. 2. Total final demands, Y , were obtained from Ref. 3. To aggregate N_j sectors, the following formula was used:

$$\overline{E}_j = \frac{\sum_{i=1}^{N_j} E_i Y_i}{\sum_{i=1}^{N_j} Y_i}$$

where \overline{E}_j is the energy content (Btu/\$ producers' price) of the output from the new aggregated sector j .

The components of GNP, in producers' prices, and the corresponding indirect energy coefficients are listed in Table A1. Herendeen's definition of indirect energy for energy products does not include waste heat and refining energy; he included that as direct energy. I consider it indirect, and correct his indirect coefficients for the energy sectors below.

	PERSONAL CONSUMPTION EXPENDITURE	GROSS PRIVATE CAPITAL FORMATION	NET INVENTORY CHANGE	NET EXPORTS	STATE & LOCAL GOVERNMENT EXPENDITURE	FEDERAL GOVERNMENT EXPENDITURE	TOTAL FINAL DEMAND	TOTAL ENERGY CONTENT
1 LIVESTOCK	98069	0	2565	1642	694	252	103222	67956
2 OTHER AG PRD	164960	0	63230	262467	4934	-753	494838	52639
3 FOREST FISH PRO	24436	0	143	87	131	-543	24254	29392
4 AG FOREST SVC	617	0	0	440	-1810	480	-273	49441
5 IRON ORE MIN	0	0	0	0	0	0	0	105822
6 NONFERRO METAL	0	0	-39	0	0	9957	9918	73026
7 COAL MIN	10802	0	4	24415	798	2822	38841	99272
8 CRUDE PETRO,GAS	0	0	327	160	0	0	487	108544
9 STONE CLAY MIN	917	0	62	740	-1634	258	343	94202
10 CHEM MINERAL MIN	126	0	-10	168	1302	263	1849	198136
11 NEW CONST	0	2173708	0	0	681171	141174	2996053	68740
12 MAIN*JANCE CONST	0	0	0	0	193126	51455	244581	66810
13 ORCNANCE	10870	0	-509	5556	132	167375	183424	42749
14 FOOD	2892167	0	49116	172142	27777	14605	3155807	57711
15 TOBACCO MANUF	282100	0	66	611	59	0	282836	26073
16 FABRICS,YARN	34546	0	128	1132	773	63	36642	89684
17 TEXTILE PRODUCTS	62148	4514	2722	1360	-3	259	71000	75162
18 APPAREL	839496	0	1523	3435	4335	1364	850153	46899
19 MIS TEXTILE PRD	85957	0	2234	1863	443	958	91455	68669
20 LUMBER WOOD PRD	11134	482	1234	3187	190	230	16457	43585
21 WOODEN CONTAINER	0	0	28	43	0	7	78	54833
22 HOUSE* FURNITURE	190245	8689	4014	467	1020	665	205100	56754
23 OTHER FURNITURE	8192	79355	1435	1885	11477	1819	104163	69639
24 PAPER	68514	0	3095	6299	2570	1946	82424	123164
25 PAPER CONTAINER	4016	0	3140	3161	3340	337	13994	108298
26 PRINT & PUBLISH	194797	0	12207	30318	25128	1408	263858	51099
27 CHEMICALS	22696	0	4946	39101	11583	56162	134488	302305
28 PLASTICS	684	0	472	2576	8	815	4555	211834
29 DRUGS,TOILET	301357	0	18557	25266	20167	5585	370932	92590
30 PAINTS	1382	0	5855	3148	185	135	10705	141299
31 PETRO REFINING	475020	0	11524	6649	16984	15405	525582	197020
32 RUBBER PRD	106147	949	6803	18477	5752	13482	151610	94244
33 LEATHER	0	0	-505	2134	0	17	1646	58251
34 FOOTWARE	186043	0	-2091	758	55	208	184973	41510
35 GLASS	13810	0	5681	5800	1875	491	27657	107649
36 STONE & CLAY PRD	12807	0	4359	6373	715	139	24293	90307
37 IRON&STEEL MANUF	614	0	8553	22402	165	2939	34673	249466
38 NONFERRO MANUF	660	1244	9376	7648	4	3034	21966	171434
39 METAL CONTAINER	0	776	4468	8017	1	636	13898	135522
40 STRUCT METAL PRD	4941	29999	5890	7155	14	2425	50424	111960
41 METAL STAMPINGS	14849	0	8640	5331	630	1619	31069	101599

TABLE AL. COMPONENTS OF 1963 ILLINOIS FINAL DEMAND (THOUSANDS OF \$)
TOTAL ENERGY COEFFICIENTS (BTU/\$)

		PERSONAL CONSUMPTION EXPENDITURE	GROSS PRIVATE CAPITAL FORMATION	NET INVENTORY CHANGE	NET EXPORTS	STATE & LOCAL GOVERNMENT EXPENDITURE	FEDERAL GOVERNMENT EXPENDITURE	TOTAL FINAL DEMAND	TOTAL ENERGY CONTENT
42	OTHER METAL PRD	34277	17094	11620	29563	459	2484	95497	74730
43	ENGINE & TURBINE	5560	20886	2778	26356	0	2829	58409	70880
44	FARM MACH	633	122634	9835	71497	860	736	206195	77100
45	CONST MACH	0	101566	16934	461889	1814	36519	618722	72254
46	MAT'L HAND MACH	0	44339	1396	47276	80	14963	108054	65691
47	METALWORK MACH	4823	130759	6770	40927	1235	4077	188591	53866
48	SPECIAL IND MACH	1295	129416	2161	51992	398	894	186156	57114
49	GENERAL IND MACH	0	85614	4062	32664	703	21588	144631	61715
50	MACH SHOP PRD	116	421	703	0	2395	2128	5763	55355
51	OFFICE MACH	5505	118074	2548	6465	6212	10769	149573	31744
52	SVC IND MACH	19616	80045	4241	9970	4086	4070	122028	64663
53	ELECTRIC IND EQP	1339	105436	1836	12749	3344	29985	154689	59102
54	HOUSEHOLD APPLIANCE	156772	7953	32649	21755	776	1223	221128	76211
55	ELECTRIC LIGHT	25910	3503	3105	11111	3043	1647	48319	60912
56	RADIO TV EQP	134494	110558	22188	51885	6562	355763	681450	36201
57	ELECTRONIC COMP	11364	5621	-725	4455	289	9501	30505	52809
58	MISC ELECT MACH	21147	13263	2001	3727	737	5288	46163	60481
59	MOTOR VEHICLE	1011262	403827	15503	27608	35978	36078	1530256	70451
60	AIRCRAFT	2195	41208	2940	5015	2	70984	122344	43437
61	OTH TRANSP EQP	43795	122350	3685	42968	1735	14553	229086	75116
62	SCIENTIFIC INST	24175	42836	8231	21078	6708	26376	129404	46543
63	OPTICAL EQP	38644	24069	1214	16049	3675	9151	92802	60417
64	MISC MANUF	201290	33722	4410	23271	5695	394	268772	57449
65	TRANSPORT	524068	38824	12329	183564	38201	59123	856109	110266
66	COMMUNICATION	328298	32775	0	175	19154	10646	291048	19481
67	RADIO TV BROCAST	0	0	0	924	935	0	1859	21043
68	ELECTRIC GAS	715693	0	0	0	48054	5018	768765	120231
69	WHOLESALE RETAIL	4783901	331744	22599	141065	6491	29117	5314917	32869
70	FINANCE & INSURANC	1044142	50	0	2321	14835	0	1061348	30177
71	REAL ESTATE	3224776	83843	0	30246	26273	8085	3373223	13401
72	HOTEL	699798	0	0	235	9076	12532	721641	35735
73	BUSINESS SVC	198273	0	0	28701	53521	129162	409657	29639
74	RES AND DEV	0	0	0	0	0	0	0	0
75	AUTO REPAIR	374474	0	0	0	5520	597	390591	33648
76	AMUSEMENT	276379	0	325	10967	-2997	5626	290300	25882
77	MEDICAL EDUC SVC	1755776	0	0	1441	41136	64606	1862959	35437
78	FED GOV ENTERPR	52076	0	0	2472	10168	3770	68486	23440
79	STATFCL ENTERPR	36148	0	0	0	1189	10087	47424	90265
80	IMPORTS	354233	11265	0	0	155	89942	455595	0
81	BUSINESS TRAVEL	0	0	0	0	0	0	0	0
82	OFFICE SUPPLY	0	0	0	0	13557	4337	17894	73109

TABLE A1 (cont.) COMPONENTS OF 1963 ILLINOIS FINAL DEMAND (THOUSANDS OF \$)
TOTAL ENERGY COEFFICIENTS (BTU/\$)

III. Direct Energy Sales to Final Demand, U.S. Total

From Ref. 2. we find that the average price of coal to final demand was 4.094 million Btu/\$. Sales were \$519.8 million, giving a total of 2128 trillion Btu.

No crude oil and gas was sold to final demand (Ref. 2).

From Ref. 2, the price of refined petroleum products to final demand was 1.06 million Btu/\$. Sales were \$10085 million (Ref. 3), giving a total of 10690 trillion Btu. Also from Ref. 2, 949,800 Btu crude were required indirectly for every dollar's worth of refined delivered to final demand; multiplying we obtain 9579 trillion Btu. Similarly, 3842 trillion Btu crude are allocated to final demand for natural gas, because 962,700 Btu per dollar's worth of gas were required. Final demand for electricity required 855 trillion Btu at 120,970 Btu/\$. These latter numbers will be used below to modify the indirect coefficients for these secondary energy types.

For electricity, 1014 trillion Btu were delivered directly at an average price of 143,500 Btu/\$.

The natural gas price was 992,500 Btu/\$, and sales were \$3991 million, for a direct energy value of 3961 trillion Btu. Gas was indirectly required for electricity sales at 101,700 Btu/\$, for a total of 718 trillion Btu.

Adding the numbers obtained above, we get the total direct energy delivered to final demand, 17993 trillion Btu.

Next the indirect energy associated with energy processing must be determined from the above information. To do this, we seek only the primary component, since we would double-count if we added the indirect crude oil and gas required for electricity to the processed natural gas required. From Ref. we have the equation:

$$\text{Primary Energy} = \text{Coal} + \text{Crude} + .5948 \text{ Electric}$$

and use it to obtain the net primary energy from the amounts of coal, crude, and electricity indirectly allocated to final demand. The factor .5948 gives the hydro and nuclear component of electricity, converted to fossil fuel equivalent. Using this equation, we obtain the following indirect energies (trillion Btu) associated with sales to final demand.

$$\text{Electricity} = 1788 + 855 + .5948 \times 1014 = 2633$$

$$\text{Gas Utilities} = 3842$$

$$\text{Refined Petroleum} = 9579$$

Subtracting the direct energy content of the deliveries to final demand, we obtain net energies of 2222, -79, and -1112 trillion Btu, respectively. The electricity is large, due to the waste heat at power plants. Gas and refined petroleum are negative, because imports of refined exceeded energy consumed domestically to refine oil. Table A2 summarizes the results.

	Direct Energy to Final Demand		Adjustment to Indirect	
	10^{12} Btu	10^6 Btu/capita	10^{12} Btu	10^6 Btu
Coal	2128	11.25	0	0
Crude	0	0	0	0
RPP	10690	56.50	-1112	-5.88
Electricity	1014	5.35	2222	11.77
Gas	3961	20.94	-79	-.42
Total	17793	94.04	1031	5.47

TABLE A2. U.S. Direct Energy Deliveries to Final Demand, 1963

IV. Indirect Energy to Final Demand, U.S.

This was obtained from the energy coefficients, \bar{E}_j , and the final demand Y_j using the equation

$$\text{Per Capita Indirect Energy} = \frac{\sum_{j=1}^{82} \bar{E}_j Y_j}{P} = 157 \times 10^6 \text{ Btu/capita}$$

where $P = 189,197,000$ was the U.S. population in 1963.¹⁶

Making the above adjustments for energy consumed indirectly to produce energy, we get a total per capita energy demand of 256 million Btu. 162 million were consumed indirectly, 94 million directly.

V. Illinois Direct and Indirect Energy Demand, 1963

The analyses of III and IV were repeated for the six components of the Illinois contribution to GNP.

Data on direct energy deliveries to final demand were available for electricity and gas.^{8,9} For electricity, residential sales (kwh converted to Btu at 3413 Btu/kwh) were assigned to personal consumption. Street lighting was assigned to state and local governments, and "Other" was split between state and federal governments proportional to their national total purchases of electricity from Ref. 3. For natural gas, the same method was used.

Data were not available for coal, so Illinois dollar sales were converted to Btu's using the national average price from Ref. 2.

Similarly, refined petroleum deliveries to final demand were not available for Illinois, so the national average (per capita) was used. This seemed reasonable because per capita gasoline consumption (Btu) was 3% lower than the national average. Dollar sales of refined petroleum products in Illinois were 7% higher than average.¹⁰ Also from Ref. 10 we see that Illinois gasoline prices were about average, and fuel oil slightly higher than average. Since

these factors appear to compensate the national average figure was used for Illinois. The need for better data is obvious.

Tables A3 and A4 summarize the Illinois direct and indirect energy demands. Per capita figures are based on a population of 10,182,000 in 1963.¹⁶

	Direct	Indirect	Total
Personal Consumption	109.64	83.43	193.07
Gross Private Capital Formation	27.95	0	27.95
Net Inventory Charge	3.27	.90	4.17
Gross Foreign Exports	15.04	13.62	28.66
State and Local Government Expenditures	10.08	2.80	12.88
Federal Government Expenditures	9.13	5.28	14.41
Total	175.1	106.03	281.14

TABLE A3. Illinois Direct and Indirect Energy Demand, 1963 (million Btu/capita)

	Direct	Indirect	Total
Coal	16.83	53.64	73.47
Crude Oil & Gas	88.37	108.86	197.23
Hydro & Nuclear	.82	9.66	10.48

TABLE A4. Illinois Energy Demand by Primary Resource Type, 1963 (million Btu/capita)

VI. Energy Mined in Illinois, 1963

From the Minerals Yearbook, we find Illinois coal production was 51,736,316 tons. This was converted to Btu's using the average Btu content of Illinois coal of 22 million Btu/ton (Ref. 2). Crude petroleum production of 73,783,000 bbl. was converted at 5.8 million Btu/bbl. Natural gas production of 9459 mcf was converted at 1035 Btu/cubic foot. Natural gasoline and LP gas production of 352,217,000 gal. was converted at 97,857 Btu/gal.

Gross hydro production of 176 million kwh was obtained from Ref. 9 and converted at the 1963 average heat rate of 10,548 Btu/kwh.⁹

Gross nuclear electric production at Commonwealth Edison's nuclear plant was 989,720,000 kwh and was multiplied by the same heat rate.⁷ It was the only operating nuclear plant in Illinois in 1963.

VII. Energy Burned in Illinois, 1963

These figures were obtained from Mr. Robert Major, Associate Mineral Economist with the Illinois Geological Survey. The figures are from preliminary worksheets and may be subject to revision, but are considered to be the best presently available. They are, in quadrillion Btu's: Coal-859.89, Natural Gas-726.25, Oil-888.84, Hydropower-1.86, and Nuclear-10.44. The gross nuclear production figure was obtained from Ref. 7.

VIII. Illinois Personal Consumption Expenditures

In Fig. 6, the 82 input/output sectors were aggregated into 18 more recognizable ones. Table A5 shows the correspondence.

CATEGORY	
Electricity, Gas & Water	68
Gasoline & Fuel Oil	31
Coal	5-10
Food & Drugs	1-4, 14, 15, 29
Wholesale & Retail Trade	69
Motor Vehicle & Repair	59-61, 75
Medical & Education	62, 63, 77
Clothing	16-19, 34
Transportation	65
Insurance & Finance	70
Real Estate & Rental	71
Hotel & Misc. Services	72
Glass & Metal	13, 35-53, 64
Appliances & Electronics	54-58
Plastics & Rubber	27, 28, 30, 32
Paper	24-26
Furniture	22, 23
Phone & Misc.	20, 21, 66, 76

TABLE A5 . PERSONAL CONSUMPTION CATEGORIES AND
INPUT/OUTPUT SECTORS



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